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MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF CORNELL UNIVERSITY.

Communicated by E. B. TITCHENER.

XIX. VISUAL READING: A STUDY IN MENTAL IMAGERY.

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INTRODUCTION.

The question before us in the present Study is: Is it possible to read without mentally hearing the words, and without feeling them in the throat, the mouth, or on the lips? Can one grasp the meaning of printed or written matter through the eye alone, without the aid of articulatory or auditory images? In other words: is it possible to pass from the visual word directly to the sense, without the mediation of articulation or audition?

The word as sign of an idea may exist in the mind in four ways: as auditory image, as visual image, and as motor image either hand-motor or articulatory. The four centers in the brain corresponding to the four ways in which a word may exist as an idea-sign are pretty well localized. If we were to judge *a priori*, we should say that two of these centers, namely the auditory and articulatory, must be more firmly organized and better correlated than the other two, inasmuch as they have been in use ever since the race began to utilize vocal signs for communication; the word has been a sound or an articulatory movement for an incomparably longer time than it has been a visual or hand-motor image. What is true of the race is here also true of the individual; the child learns to speak and hear words as words some time before it learns to write or to recognize the visual word. Besides the advantages of priority of development in the race and in the individual, the auditory and articulatory centers have the further advantage of being much more constantly in use with the majority of people than the visual and hand-motor centers. For these reasons, then, one is led to conclude that the auditory and articulatory word must necessarily be a much more persistent and prominent factor in language than the visual or hand-motor word.

This *a priori* conclusion is borne out by the facts gleaned from experiment, and by everyday observation. Three out of four

of the subjects of this Study have both audition and articulation in ordinary reading; the fourth has only audition, but this is very persistent. All said that they usually thought in auditory terms, and some have the articulatory accompaniment as well. On the other hand, none of them see words (have the visual word) when thinking or when talking.

It is a significant fact that the subject who seems to be most predominantly visual has had the greatest difficulty in deciding whether she does or does not see the word while talking. When conscious of being under experimentation, she always sees the words as they are spoken. The method employed here was to induce the subject to talk, while unconscious of the experiment, and then ask her to introspect as to whether she saw the words as spoken. Invariably, when she was thus asked, the words last articulated would flash before her mind in visual terms. For some time it was hard to discriminate between visualization thus occasioned by the question, and the real composition of the mind during speech. After some practice, however, introspection gave a definite verdict that there was no visual imagery of spoken words. The other subjects, who were not so decidedly visual, said that they never or scarcely ever saw words as they thought or talked; some even found that an effort was required to see the words spoken by themselves, even when they wished to do so. The fact that the subject who was most decidedly visual in type found it difficult to determine whether visual images of words were present during speech, while others of a less decided visual type found little or no difficulty in determining that they were absent, is a useful confirmation of our *a priori* theory. It further shows that the prominence of the visual, auditory or articulatory word depends somewhat upon the type of the individual.

Another element of scarcely less importance than the preceding would seem to enter here. Since, as we have seen, the peculiar prominence and persistence of auditory and articulatory imagery are due to its greater use by the race and the individual, we should naturally suppose that practice or continued use would have the same effect in bringing visual imagery into prominence. This seems to be a correct conclusion: for the degree to which audition and articulation are banished from reading, and the extent to which visual words occur in ordinary talking, appear to depend upon the amount and kind of reading done by the subject. If he has intellectual tastes, and has been accustomed to studious habits and consequently to much reading from youth up, other things being equal, audition and articulation will tend to become less and less distinct and finally perhaps fade out entirely, while the visual word will become more and more prominent. This conclusion is borne out by our ex-

periments, so far as they go, although four subjects could furnish only very meager data for so general an inference. The subject with whom the auditory and articulatory elements were of little importance, and the visual of somewhat more than ordinary importance, was D., a Graduate Student about to take the examinations for the doctorate in philosophy. She must necessarily have done much reading. A second subject, Wh., was a second year candidate for the philosophical doctorate, and had probably read less than D., but much more than the average college student. With Wh. the articulatory element was almost entirely lacking. The visual word was not developed to any great extent; yet he could see the words spoken by himself, with a little effort. The other two subjects, Wi. and O., a Senior and a Junior respectively, differed but little in the prominence of the auditory and articulatory factors, the articulatory being a little more prominent in the former than in the latter. Neither saw the words that he used, without a considerable effort.

I. MEMORY TYPES.

As already indicated, the mental constitution or type of the individual has much to do in deciding the place that each sense shall have as a factor in reading. It is quite important, then, in experiments of this kind, that the type shall be known. The first method employed to ascertain this fact was as follows. (a) A word is written on the blackboard by the experimenter, the subject having his eyes closed. At the signal "Now," the subject opens his eyes and looks at the word. The word is then immediately erased and the subject asked to say whether he had auditory and articulatory images of the word, and what further imagery was suggested by the word as a word. We give here replies, one from each of the four subjects, each being as far as possible characteristic. Following this is a tabular form, showing the results as to kind of imagery suggested by the word in each case.

(1) The word "Slate-roof" was placed before Wi. Introspection was as follows. "I heard the word very low, as if spoken by myself. There was a little movement of, or effort to move, the tongue. I saw the top of the Armory with a slate-roof on it, a good distance off. The slate was grey." (2) The word "organ" was presented to Wh. Introspection was as follows. "I heard the word but had no articulatory feeling. I started indistinctly to visualize a general organ in front of me, then I had the sensation of turning towards the Chapel, and visualized the organ there. I heard some notes in the sound of my own voice, like *too, too, too, too*." (3) The word "steam-whistle" was presented to D. Introspection was as follows.

"I had no articulatory or auditory images of the words: the meaning just came from seeing the word. First I heard the high, shrill whistle of a locomotive, then I had a visual image of the whistle with the steam all around it, as it is sometimes seen. In the background was a locomotive, very ill defined."

(4) The word "Ink-stand" was presented to O. He introspected as follows. "I heard the word; and there was a slight articulatory feel on the end of the tongue. A glass ink-stand flashed before me, about arm's length away."

The imagery of the different subjects was studied by another method also. (b) Each was asked to reproduce the matter read in the experiments presently to be described, and then to tell just how he reproduced, *i. e.*, whether in auditory terms, visual terms, etc. This experiment, as well as throwing light upon the type of the subject, was a means of assuring the experimenter that the subject had actually read the paragraph assigned rather than merely glanced it over.

The first experiment, in which the words were presented, showed all four subjects to be of a decided visual type. Both the methods showed D. to be distinctly visual in type. The visual images were not especially clear-cut, but they were profuse and detailed, *i. e.*, all parts of an object or scene had their counterparts in the visual image. The image could be recalled and examined at will some time after it had vanished. The subject is able to read from a visualized page, not of course with the degree of surety that would accompany the reading of a real page, but still with tolerable accuracy. She sometimes reproduced short paragraphs in this way. The usual way of reproduction in such cases was, however, to reproduce from the visual pictures formed when reading the paragraph, with aid also from various visualized words. This subject, as we have said, was the most decidedly visual of the four.

The next in order was Wh. His visual imagery was as clear-cut, perhaps, as that of D., yet it lacked the detail and profusion. In his imagery in general he drew upon more senses than the others, *i. e.*, his type was more mixed.¹ Notwithstanding the fact that he was decidedly visual, he had a strong tendency to be ear-minded. He usually heard as well as saw that which was suggested by a word, the visualization invariably coming first, however. In reproducing the paragraph Wh. depends mainly on the visual picture, the visual word and the

¹ Wh. differs from D. in having more images as regards variety, but less profuse and detailed imagery as regards quality. It would be a very interesting study to determine whether there is any special relation of dependence between these two factors; to ascertain, *e. g.*, whether detail is inversely proportional to variety of imagery, as this instance seems possibly to indicate.

TABLE OF IMAGERY.¹

WORDS SHOWN.	D.	WH.	W.	O.
Driftwood	V	V	V	
Waves	V	V	V	
Violet	V & M	V	V	
Book	V & P	V	—	
Salt	Gus & V	Gus. V. M.	V	
Quail	V & A	V	Gus. & V	
Sea-shell	V	V & A-verb	V?	V
Waterfall	V	V & A	—	V
Rose	V	V & olf.?	V	V
Wet sidewalk	V & M	V & org.	V & olf.	V
Railroad	V & A	V	V	—
Springtime	V	V	—	V
Infinity	—	—	A-verb	V
Fog	V	V & org.	V & A & A-verb	A & A-verb & V
Dog	V	V	V	V
Leaves	V	V & A & A-verb	V	V
Expanse	V	M & V	V	—
Bright day	V	—	V & A?	V
Brimstone	V	—	V	V
Forest	V	V	V	V
Whistle	V & A	A	V	A
Summer night	V & olf.	A & T	V & A & A-verb	V
Steam	V	V & A	V & A	V
Picnic	V	V	V	V
Fog-horn	V	V	—	V
Landscape	—	—	V	V
Fire	—	V & A	V & T	—
Blackbirds	—	V & A	V & A	V
The morning wind	—	A & V	V & A	A
Glowing horse shoe	—	V & A	V	V
Flute	A & V	V. M. A.	—	A & V
Ice-water	T & V	V. M. T.	V	V?
Brass-band	V	V & A	V & A	—
Horse	V	V & A	V	V
Bees	—	—	V & A & A-verb	—
Robin	V & A	—	V	V
Chimes	V & A	—	V & A & A-verb	V
Kerosene	V	—	V & org.	V
Grass	V	—	A & A-verb	V
Red-squirrel	V	—	V	V
Skaters	V	—	V	—
Lamp	V	—	V & olf.	V
Blue-book	V	—	V	V
Tobacco	Olf. & V	—	V & olf.	V
Steel	—	—	A & A-verb	V
Slate-roof	V	V & A	V	V
Partridge	V	V & A	V	V
Distant bell	V & A	V & A	V & A	—
Street car	V. A. P?	V	V	V
Camphor	Olf.	V. M. olf.	V	V
Knife	V	V. M. A.	V	V
Cigar	Olf. & V	V. P. gus.	V & gus.	V
Sandy bar	V	V. A. T.	V & A & A-verb	V
Deep-voiced ocean	A & V & A-verb	A & A-verb & V	V & A	V
Forest primeval	V	V & A & A-verb	A & A-verb	V
Piano	V	V & A	V	V
Steam	V. A.	V & A & P	V	V
Valley	V. A.	V	V	V
Envelope	—	V. A. M. gus.	V	V
Lavender	—	A & A-verb V	V	—

¹ In this Table, V = visual; A = auditory; M = muscular; T = temperature;

TABLE OF IMAGERY.—*Continued.*

WORD SHOWN.	D.	WH.	W.	O.
Rising tide		V & A	V	V
Watch	V & A	V & A	V	V
Sleigh-bells	V. A.	A & V	V	A
Key	V	V & M	V	V
Engine	V & A		A & V	V
Violin	V & A		V & A	V
Headache	S	V	—	—
Organ	V	V	V	V?
Bicycle	V & M	V & M	V	—
Chickadee	V & A	V & A	V	—
Steam-whistle	A & V	V & A	V	—
Ink-stand	V & G	V	V	V
Light	V	—	V	—
Smoke	V		V	V
Soldiers	V		V	—
Darkness	V		—	—
Postage-stamp	V		V	V
Church-steeple	A & V		V	V
Umbrella	V		V	V
Box	V	—	V	—
Child	V	V & A	V?	V
Empty barrel	V	V	V	V
Flies	V & A			
Foot-ball	V & A			
Clock	V			
Machine	V & A			
Eye	V			
Xylophone	V & A			
Trench	V			
Newspaper	A & V			
Sparrow	A & V			
Hen	V			
Tennis court	V & M			
Field of grain	V			

S = strain; olf. = olfactory; org. = organic; P = pressure; gus. = gustatory; A-verb = auditory-verbal. A blank space indicates that the word was not shown to the subject in question; a — that introspection revealed nothing but visual-verbal elements.

accompanying auditory word. Wh. is a musician, and sings as well as plays. He says that he invariably has a tune in his head when not engaged in serious study or thinking; he sometimes chews in time with a tune when eating.

Both methods show Wi. to be a visual, yet he depends on other senses to some extent. In reproduction the visual picture suggested by the sense is the main factor; he is, however, assisted by visual words. The words thus visualized are always heard as well as seen. His images are fairly clear and well defined. They are not especially detailed or profuse.

The experiment in which words are presented shows O. to be a visual, yet his visual images are indistinct and ill defined. He often visualizes pictures of objects rather than the objects themselves. In the reproduction of matter read, visual pictures do not play an important part; in fact they are almost entirely absent, and he says that he reproduces from the "sense." He seems inclined to identify 'sense' with audition, and to say that he reproduces in auditory terms. He always, however, gives back the paragraph in his own words rather than in the

words of the book: which suggests that auditory images are not really a prominent factor in his reproduction. It is quite probable that his mode of reproduction is very complex, being composed of elements from many of the senses. These elements by use have become so fused and knit together that the resulting complex seems like a unity, which does not resemble the imagery of any one sense, and can be given no better expression than by the phrase 'reproduction from the sense.'

II. READING BY VISION ALONE.

In attacking the problem of the possibility of reading without articulation and audition, two general methods are available. One might try an indefinite number of people until one or more should be found who could read without the articulatory or auditory accompaniment; or one might select three or four subjects, and, placing them under conditions which would tend to decrease or fade out the auditory and articulatory elements, so train them that it should become possible for them to read by the aid of the eye alone. Either method, if pursued far enough, would furnish a solution of the problem. The former, however, hardly seems practicable. Too much time would be required to train each subject to introspect well enough for scientific purposes. And, even were this time at our command, it would be difficult to obtain the required number of subjects. Moreover, there is a bare chance that reading without audition and articulation is possible, and yet that no one under ordinary conditions would read in that way. The second method is, therefore, the one followed here.

The nature of the problem makes it difficult to use any but general checks upon the pure method of introspection. Hence, with one exception which will come out later, the results here recorded are the product of introspection under general control. The subject performed the experiment as directed by the experimenter, and then gave his introspection in answer to various questions, which were calculated to bring out the information required. Great care has been taken to avoid what sometimes occurs in the act of introspection, the reading into the introspection of that which occurs after the experiment is concluded, and at the time of introspecting, rather than the giving a true account of what happened when under the conditions of the experiment.

(a) The first specific method employed was as follows. The subject was given a book and asked to read a certain paragraph as rapidly as possible. This was with the expectation that the eye would outrun the ear, thus leaving it behind, and allowing the auditory element to drop out. The method was varied by asking the subject to read the first part of a paragraph at ordi-

nary speed and the latter part as rapidly as possible and *vice versa*, thus making possible a comparison between the imagery aroused when reading at the normal speed, and that aroused when reading at the maximal rate. The results obtained were fairly constant with three subjects, but varied with the fourth. With the three, the audition and articulation were less prominent than in ordinary reading. They were less prominent, because a less noticeable factor in consciousness. Two of these subjects (O. and Wh.) say that some small words are not heard at all, and that others are not heard distinctly. Besides this general tendency to fade the images seen in rapid reading, O. and Wh. find another difference. They hear the words in each case about as they would articulate them. When reading slowly there is plenty of time for full round articulation, but in rapid reading the words are heard as slurred and indistinctly pronounced, as when talking rapidly. With D. rapid reading fades both audition and articulation, the latter sometimes being absent altogether, while the former becomes a very indistinct factor. Wi. finds that, when he is trying to hurry the reading, the auditory element becomes more distinct and noticeable; the articulation, however, sometimes becomes less distinct. On the whole, then, the general tendency of the method seems to be to make the auditory and articulatory factors more indistinct. In no case has it succeeded in banishing the auditory element; but, on the other hand, Wi. O. and D. often say that they had no articulation.

(b) The second method employed was calculated to shut off, if possible, the articulatory element, while it also affected audition. The method was as follows. The subject was asked either to say the alphabet aloud or to whistle a tune while reading. The results of this method were somewhat startling. It completely removed all traces of articulatory movement, so far as the possibility of discovering this by introspection is concerned. All subjects throughout the year, with very few exceptions (D. thought a few times that there was a slight tendency to articulate, but by far the great majority of her judgments say that there is no articulation), found no articulation present under these conditions.

It was thought that there might be certain articulatory movements during the intervals in which the organs were not occupied in forming the letters or the tones, and that on account of the general articulatory movement, accompanying the saying of the alphabet or whistling, these interstitial movements would be overlooked by introspection. To guard against this, the method was varied by asking the subject to read while articulating a certain letter, prolonging the letter as much as possible. The results only verified those of the original method. Artic-

ulation was completely eradicated. The method was varied still farther. To ascertain whether conscious voluntary movement of any part of the body might not remove the tendency to articulate, in the same way as the above method,—or at least produce the same apparent result by distracting the attention, thus showing the first results to be a mere distraction of attention, rather than a removal of the tendency to articulate,—the subject was asked to clap the hands, swing the feet, trot the foot, etc., while reading. These movements did not seem to interfere in the least with the articulatory tendency. The result indicates that the results obtained from the two former methods were not merely apparent but real.

The Verdin laryngograph was now applied to the throat, as a check to the introspective method in its application to articulation. This instrument indicates movement of the larynx by tracing a curve on the kymograph cylinder. It can, of course, detect only actual movements of the larynx and movements of some magnitude; it cannot indicate subliminal movements, or the presence of a purely mental articulatory image. The laryngograph was supported from the chest, so that the breathing movements caused the pointer to trace a regular wave-like curve on the cylinder even when there was no movement of the vocal organs. The method first pursued was to obtain a breathing curve, and then lower the cylinder and trace another curve just above the breathing curve, the subject reading silently while this second curve was being traced. These two curves, one above the other, enabled the experimenter to compare the one with the other, and detect any irregularity indicating movements of the larynx. It was soon found that, although the instrument allowed itself to be adjusted so that very slight movements could be detected, it was very hard to determine just what irregularities of the curve were the result of articulatory movement proper, and just what were due to some accidental movement of the subject. A method which should allow for more precision and certainty was therefore necessary. The following method was then devised. After tracing the breathing curve, the cylinder was lowered, and a curve was traced just above it while the subject read aloud in time with a metronome, reading one word at each beat. The cylinder was then again lowered, and the subject read silently the same matter as before in time with the metronome,—thus tracing a third curve above the other two. The part of curve 2 which represented the articulatory movement for any word had its duplicate in the curve above, in case there was any articulatory movement when the subject read silently. This made the detection of any movement of the vocal organs a fairly simple matter; yet the

reading in time with the metronome favored articulation, rather than tended to check it.

The results of the laryngographic test correspond very well with the introspection of the subjects. With Wh. and D. the curves show no articulatory movement. Wh. never finds any articulatory tendency when he introspects, while D. never finds movement, but sometimes has the articulatory feel. The curve indicated movement in the case of Wi. and O. Wi. is a mouth reader, and almost always finds articulation present when he introspects; while O. finds articulation present to a greater or less extent.

The success in shutting off the articulatory element, by the occupation of the articulatory centers with other stimuli, suggested the idea that the auditory factor might be eliminated in a similar way. The method was this. (c) The subject read a paragraph while whistling or saying the alphabet, and the experimenter played on a xylophone at the same time. The experiment was intended to shut off both articulation and audition. The results, though not so startling as those of the former method, are nevertheless quite decided. D. found that both articulation and audition were usually absent when she read under these conditions; that the meaning came as a direct result of the visualization without the mediation of auditory or articulatory elements. Wh., in whom articulation is invariably absent, and audition invariably present, finds that his auditory images are a much less distinct and noticeable element, when reading under these conditions. They do not seem as loud and do not occupy as prominent a place in consciousness as ordinarily. The results obtained from O. are very similar to those from Wh., except that, while ordinarily having articulation, he now finds it absent. Wi. finds the articulatory element eliminated, but the auditory still persists with as much vigor and force as ever.

The methods thus far described are those which were the most fruitful. Another, employed as a possible check upon the foregoing, was suggested by Dr. T. L. Smith, who was experimenting at the time upon a cognate problem. It takes advantage of the fact that there are certain classes of consonants whose formation requires distinctly different positions of the vocal organs (dentals, labials, gutturals). The subject was seated before an exposure-screen, with eyes closed. At a signal the eyes were opened to see a letter exposed on the screen. Shortly (1-1.5 sec.) after the signal for opening the eyes was given, and at a moment when the subject would have had about time to apperceive the letter, the experimenter pronounced a word containing an initial or final consonant taken from the same group as the letter exposed (*e. g.*, expose *t* and say *dot*; expose *b* and say *pelt*). This procedure was varied by ex-

posing, for example, a dental, and pronouncing a word beginning or ending with a labial or guttural. The value of the experiment in the present case would lie in a comparison of the introspections under the two different conditions. For Miss Smith had found that when the exposed letter was followed by a word beginning or ending with a similar letter, the subject invariably saw the word pronounced, but with the letter exposed in the place of the true initial or final letter. When, *e. g.*, *t* was exposed, and *dot* pronounced, the subject saw *tot*. On the other hand, when the letter was followed by a word whose initial or final letter belonged to a different class, the subject saw the word pronounced with the exposed letter hovering about in space near the incongruous initial or final. When, *e. g.*, *d* was exposed and *pelt* pronounced, the subject saw *pelt*, but somewhere near the *p* he also saw the *d*. The *d* "seemed to be trying to get into the word." The above are results obtained by Miss Smith from a subject whom we had supposed to be of a practically exclusively visual type. They showed that there was an incipient tendency in this subject to articulate, or at least that there was something besides the visual element as a factor in reading. This element, which had escaped introspection, was discovered by this method. It therefore seemed worth while to employ the same procedure with D., with a view to discovering whether there was with her, too, this other and elusive element in reading. The following are a few of the most characteristic results.

(1) Exposed *d* and said *then*.

"The auditory sensation of the word, and the visual sensation of the letter both came at the same time; then the visual image of the word behind and to the left of the letter, and having no connection with the letter whatever."

(2) Exposed *t* and said *throat*.

"The two sensations (aud. and vis.) came together; then came the visual image of the word, and a visual picture of the inside of the throat. There was no connection between the visual image of the word, and the visual sensation of the letter."

(3) Exposed *b* and said *top*.

"The two sensations came simultaneously; then a visual image of the word and of a top; also the actual image of the feel of a top between the fingers."

These and many similar results show clearly that with D. there was *no* incipient tendency to articulate. In general the letter exposed and the word articulated by the experimenter were separately and distinctly perceived, no relation existing between the two. D.'s introspection, then, is verified by this check.

(d) Other methods were used without any decided results that would help in solving the problem before us; *e. g.*, a word was selected from a paragraph and placed on the blackboard.

The subject was asked to look at the word, and then glance rapidly down the page until he found it, getting the sense of the page as far as possible. He then gave his introspection and stated whether he had any auditory or articulatory images of the words glanced over. Little resulted from this method, except that the word was usually found before the subject had reached it in reading. This shows that the eye is appreciably ahead of the sense in reading, a fact which has been pointed out by others.

To see what effect a strange or new element in the kind of letters used would produce, the subject was asked to read matter in which the long S was used. Three of the subjects had distinct auditory images of a sound which is a cross between an S and F, a sound like the lisped F. The fourth subject did not have this experience, but sometimes read the S as an F, and had to reread to correct the error.

There are certain conditions under which the articulatory, auditory, and visual imagery are much more distinct than usual. When the subject for any reason stumbles on a word, and has difficulty to grasp it at first, or tries to read a foreign word, the articulatory and the auditory imagery are much more marked; they seem to serve as aids to overcome difficulties in obtaining the sense. In reading dialogue the auditory element is more distinct than usual, with some subjects. The visual imagery of italicized or capitalized words is more persistent than it is for words not thus made conspicuous.

SUMMARY.

The results of these experiments as a whole are as follows:

- (1) The auditory element is a much more persistent factor in reading than articulation.
- (2) Both articulation and audition are to be regarded as aids in reading, rather than absolutely necessary elements.
- (3) The prominence of the auditory and articulatory elements in reading depends upon the type of the individual, and upon the amount and kind of reading done by him.
- (4) It is possible to read without articulation and audition.